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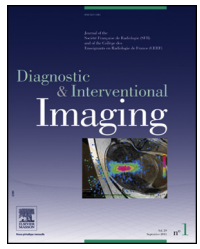

ORIGINAL ARTICLE / *Pediatric imaging*

The use of computed tomography and nuclear medicine examinations in paediatric oncology: An analysis of practice in a university hospital

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Abstract
Purpose: The purpose of this study is to evaluate, in terms of number of examinations and how effective doses are distributed by location and chronology, the use of CT and nuclear medicine examinations in the management of paediatric oncology patients.
Materials and methods: This was a retrospective and descriptive study that included 57 children (13 with neonatal neuroblastoma, 18 with renal tumours, and 26 with lymphoma) over a 5-year period, with the length of monitoring ranging from 1 to 7 years. All CT scans and nuclear medicine examinations were counted, and the effective doses calculated.
Results: The majority of the examinations were performed during the first year of management. The cumulative effective doses ranged from 7—152 mSv. The lymphoma group received the highest doses, but fewer than 10% of children received in excess of 100 mSv, as against 40% in the North American study published by Chawla et al.
Conclusion: The usage of irradiating diagnostic radiological examinations in paediatric oncology produces considerable effective doses, which must lead us to consider evaluating our practices, exploring all possible ways to improve protection from radiation, especially in terms of justifying investigations and using alternatives.

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Over the course of more than two decades, we have seen a continued increase in the number of imaging examinations performed, especially CT scans. In parallel, worries over the risk of the carcinogenicity of ionising radiation continue to grow, both in the medical and scientific world and for the general public, which has led the authorities to legislate on protection from radiation. In this area, the paediatric population has been subject to particularly close attention because, due to their cellular sensitivity, children are more vulnerable to ionising radiation and the suspected long-term effects are even more harmful in these populations with a longer life expectancy.

Chronic diseases that require radiological monitoring were the first to be questioned from the viewpoint of radiation protection, but because of the seriousness of paediatric oncological disease, it has never been the focus of discussions in this area. Recently, two North American studies looked at children monitored in oncology departments: one studied all imaging modalities, demonstrating that CT and nuclear medicine examinations were the greatest emitters of ionising radiation in diagnostic imaging, with major variations between different types of tumours; in this study, 40% of children were given a cumulative effective dose of 100 mSv and 22% a cumulative dose of 200 mSv [1]. In the second study, which took in positron emission tomography combined with computed tomography (PET-CT), 27% of the children were given a cumulative effective dose of 100 mSv and 10%, 200 mSv [2].

In the absence of a similar study in Europe, we looked at the practices in our establishment where there are specialised paediatric radiology and oncology departments that use examination protocols and monitoring strategies for oncological disease which follow the French and European recommendations [3].

The purpose of this retrospective and descriptive study is to evaluate the number of examinations and the effective doses delivered to these children, as well as how they are distributed around the body and chronologically over the course of management, and to propose possible avenues to consider for changes in practices.

Material and methods

Study population

This was a retrospective study into 57 children who were monitored in paediatric oncology at Clocheville University Hospital in Tours and had been diagnosed with cancer between 01/01/2005 and 31/12/2010.

Three groups of disease were chosen: neonatal neuroblastomas, defined by diagnosis during the first year of life, renal tumours, principally nephroblastomas, and lymphomas (both Hodgkin lymphoma and non-Hodgkin B-cell lymphoma).

Information collection

For each patient, demographic and clinical data were gathered from the patients' medical records: age, sex, type of cancer and location, treatment (radiotherapy, chemotherapy, surgery).

Radiological data was gathered using a radiological information system (Xplore® from the company EDL) and PACS (Horizon Medical Imaging ™ from the company McKesson). For each child, all computed tomography (CT) and nuclear medicine (NM) examinations carried out starting from diagnosis and up to 31/12/2011 (or at least one year of monitoring) were brought together, and the time to the examination from the date of diagnosis and age of the child at the time of the examination were recorded. The number of non-irradiating examinations (sonography, MRI) was also counted in order to assess the place of these modalities as alternatives to irradiating investigations in our practice.

CT scans were carried out using protocols that adjusted the voltage and the radiation output according to the child's body type following recommendations from the Société Francophone d'Imagerie Pédiatrique et Prénatale (French society of paediatric and prenatal imaging) and the paediatric Niveaux de Référence Diagnostiques (NRD) (diagnostic reference levels) [3]. The data collected from the PACS system (DICOM data and images from the examinations) were: anatomical region investigated, number of times each region was investigated, exposure length, volume computed tomography dose index (CTDIvol), and the Dose Length Product (DLP).

When a single spiral CT of the chest, abdomen and pelvis was performed, the respective DLP for each anatomical region was not initially available; it was therefore necessary to determine, by consulting the images from each examination, the exposure length that corresponded to each of these anatomical regions. The DLP by anatomical region was obtained by multiplying the exposure length in centimetres by the mean CTDIvol of the examination.

In the rare cases when none of the dosimetric information (DLP, CTDIvol) was available (fewer than 5% of examinations), the doses were estimated based on the voltage (kV) and radiation output (mAs) as these parameters are always available (DICOM data for each image).

The data gathered for the nuclear medicine examinations were: type of radiopharmaceutical injected and its activity in MBq for scintigraphy, as well as the same parameters as for CT scans if the examination was PET-CT scan or a single-photon emission computed tomography combined with computed tomography (SPECT-CT). The activity of the radiopharmaceutical injected was compliant with the recommendations from the European Association of Nuclear Medicine, and depended on the child's weight [4—7].

Estimation of the effective dose

The cumulative effective doses delivered were calculated based on DLP taking two different multiplying factors into account: firstly a coefficient for conversion of tissue sensitivity based on the Monte Carlo model [8], specific to the anatomical region and the age of the child, and secondly a correction coefficient that took into account the diameter of the phantom that was used by the manufacturer to calibrate equipment [9].

In nuclear medicine, the effective doses from the injection of radiopharmaceuticals were obtained by multiplying the activity injected (in MBq) by a conversion coefficient that is specific to the radiopharmaceutical, takes the age of